REMARKS

Favorable reconsideration and allowance of the claims of the present application are respectfully requested.

In the Office Action dated March 4, 2009, Claims 1, 2, 4 - 6, and 9 - 11 stand rejected under 35 U.S.C. § 102(e) as allegedly anticipated by U.S. Patent No. 6,846,756 B2 to Pan et al. ("Pan" hereafter). Claims 5, 7, 9, and 20 stand rejected under 35 U.S.C. §103(a) as allegedly unpatentable over Pan.

Concerning the anticipation rejection, it is axiomatic that anticipation under § 102 requires that the prior art reference disclose each and every element of the claim to which it is applied. In re King, 801 F.2d, 1324, 1326, 231 USPQ 136, 138 (Fed. Cir. 1986). Thus, there must be no differences between the subject matter of the claim and the disclosure of the prior art reference. Stated another way, the reference must contain within its four corners adequate direction to practice the invention as claimed. The corollary of the rule is equally applicable: Absence from the applied reference of any claimed element negates anticipation. Kloster Speedsteel AB v. Crucible Inc., 793 F.2d 1565, 1571, 230 USPQ 81, 84 (Fed. Cir. 1986).

Applicants respectfully submit that the claimed structures, as presently pending, are not anticipated by Pan since the applied reference does not disclose the claimed features. Specifically, Pan does not disclose an organo-silicate glass (OSG) dielectric material having a plasma treated surface layer that provides improved adhesion to an overlying lower hardmask comprising a dielectric material, yet is substantially undamaged.

In the outstanding Office Action, the Examiner identified a refractory metal adhesion/barrier layer 34 (col. 9, lines 8 -13 in Pan) as a lower hardmask. The Examiner alleged that the refractory metal adhesion/barrier layer 34 comprises a dielectric material. In support of the Examiner's allegation, the Examiners states that "metal nitride such as tantalum nitride,

tungsten nitride, titanium nitride, etc. is considered as the dielectric material because each of the above cited metal nitride has dielectric properties.

It is established in the art that in order for any material to be a dielectric material, the material must be **electrically non-conducting**. In support of this statement, Applicants submit five definitions of a "dielectric material."

The first definition is provided in a web page printout of the website of University of Bolton, which offers online postgraduate courses in the electronics industry, at http://www.ami.ac.uk/courses/topics/0100_gls/glossary/glossd.htm as captured at 10:35 p.m. on March 21, 2009. The first definition states "insulating material: one that **conducts no current** when voltage is applied across it." (Emphasis added by Applicants.)

The second definition is provided in a web page printout of Wikipedia at http://en.wikipedia.org/wiki/Dielectric as captured at 10:36 p.m. on March 21, 2009. The second definition states that "a dielectric is **a nonconducting substance**, i.e., an insulator." (Emphasis added by Applicants.)

The third definition is provided in a web page printout of a medical dictionary entry of the freedictionary.com at http://medical-dictionary.thefreedictionary.com/Dielectric+materials as captured at 10:37 p.m. on March 21, 2009. The third definition states that a dielectric is "said of an insulating substance through which an electric force is acting or may act by induction and **without conduction**." (Emphasis added by Applicants.)

The fourth definition is provided in a web page printout of an electronic version of a chemistry dictionary at http://www.chemicool.com/definition/dielectric.html as captured at 10:38 p.m. on March 21, 2009. The fourth definition states that a dielectric material is "a

nonconductive material; an insulator. Examples are silicon dioxide and silicon nitride" or "a material applied to the surface of aceramic or preformed plastic package to provide functions such as **electrical insulation, passivation** of underlying metallization, and limitations to solder flow. (Emphasis added by Applicants.)

The fifth definition is provided in a web page printout of the website of Honeywell, http://content.honeywell.com/sensing/prodinfo/thermalfuses/thermalglossary.asp, as captured at 10:38 p.m. on March 21, 2009. The fifth definition provides that a dielectric material is "a **non-conductive, insulating material** that separates the current carrying area from the application in both thermostats and heaters." (Emphasis added by Applicants.)

Thus, **a dielectric material does not conduct electricity by definition**. Therefore, a conductor material or a semiconductor material, which conduct electricity fully or to some degree cannot be a dielectric material.

It follows that if any material is more conductive than a semiconductor material, that material must be a semiconductor material or a conductor material, but cannot be an insulator material.

The values of electrical conductivity for representative semiconductors are well known.

For example, the electrical conductivity of silicon is about 10 / Ohm-cm (or 1,000 / Ohm-m). In support of this statement, Applicants submit a web page printout of http://www.carondelet.pvt.k12.ca.us/Family/Science/ GroupIVA/silicon.htm as captured at 10:59 p.m. on March 21, 2009. Further, the electrical conductivity of germanium is about 2.1739 / Ohm-cm (or 217. 39 /Ohm-m). In support of this statement, Applicants submit a printout of http://www.carondelet.pvt.k12.ca.us/Family/Science/GroupIVA/germanium.htm as captured at 10:59 p.m. on March 21, 2009. Thus, any material having electrical conductivity of 2.1739 /

Ohm-cm cannot be a dielectric material, but is a semiconductor or a conductor.

Applicants submit that the electrical conductivity of tantalum nitride is greater than the electrical conductivity of silicon or germanium. In support of this statement, Applicants submit an article by H. B. Nie et al, "Structural and electrical properties of tantalum nitride thin films fabricated by using reactive radio frequency magnetron sputtering," APPLIED PHYSICS A-MATERIALS SCIENCE & PROCESSING 73 (2): 229-236 AUG 2001, and a web page printout that substantiates that this article was accepted for publication as cited.

The abstract of the article by Nie et al. discloses that a TaN thin film having a resistivity of 6.0 mOhm-cm was obtained by the deposition method that the authors employed. The conductivity of the TaN film was obtained by taking the inverse of the resistivity. Thus, the conductivity of the TaN film is (6.0×10^{-3} Ohm-cm) = 166.7 / Ohm-cm. Considering that thin films in general have a lower conductivity than bulk films, the conductivity of TaN is in general equal to, or greater than, 166.7 / Ohm-cm. Comparison of the conductivity of TaN and the conductivities of silicon and germanium shows that the conductivity of TaN is at least one order of magnitude greater than the conductivity of silicon, and is almost two orders of magnitude greater than the conductivity of germanium. Thus, tantalum nitride is more conducting than exemplary semiconductor material, and cannot be a dielectric material by definition.

Applicants submit that the electrical conductivity of tungsten nitride is greater than the electrical conductivity of silicon or germanium. In support of this statement, Applicants submit the first page an article by Byung Lyul Park et al. "Characteristics of PECVD Grown Tungsten Nitride Films as Diffusion Barrier Layers for ULSI DRAM Applications," Journal of Electronic Materials, Vol. 26, No. 2, 1997. Applicants observe that only the first page of this article has been provided due to the difficulty of obtaining the full article.

The abstract of the article by Park et al. discloses that the resistivity of as deposited films was 160 μΩ-cm (which is 1.6×10^{-4} Ohm-cm), and decreased to 50 μΩ-cm (which is 5×10^{-5} Ohm-cm) upon annealing. Correspondingly, the conductivity of the as deposited film was 6.25×10^{3} / Ohm-cm or 2×10^{4} Ohm-cm. Even the as deposited tungsten nitride film had a conductivity that is more than two orders of magnitude greater than the conductivity of silicon. The annealed tungsten nitride film had a conductivity that is at least three orders of magnitude greater than the conductivities of silicon or germanium. Thus, tungsten nitride is more conducting than exemplary semiconductor materials, and cannot be a dielectric material by definition.

Applicants submit that the electrical conductivity of titanium nitride is greater than the electrical conductivity of silicon or germanium. Specifically, the electrical conductivity of titanium nitride is about 9.09×10^{4} / Ohm-cm (or 9.09×10^{6} / Ohm-m). In support of this statement, Applicants submit a web page printout of http://www.carondelet.pvt.k12.ca.us/ Family/Science/ GroupIVA/silicon.htm as captured at 10:59 p.m. on March 21, 2009. Comparison of the electrical conductivity of titanium nitride with the electrical conductivity of silicon or germanium shows that the electrical conductivity of titanium nitride is greater than the electrical conductivity of silicon or germanium by four or five orders of magnitude. Thus, tantalum nitride is more conducting than exemplary semiconductor materials, and cannot be a dielectric material by definition.

Thus, each and every material that the Examiner alleged to be a dielectric material, i.e., tantalum nitride, tungsten nitride, and titanium nitride, has a greater conductivity than two semiconductor materials, i.e., silicon and germanium. Further, Applicants submit that silicon and germanium does not represent semiconductor materials having the lowest conductivity, but

are representative of typical semiconductor materials as two of the most widely used semiconductor materials.

The discussion above establishes that none of the materials that Pan discloses for any element that may be identified as "an overlying lower hardmask" can be properly classified as "a dielectric material." Thus, Pan does not disclose "an overlying lower hardmask comprising a dielectric material."

In contrast, Claim 1 of the instant application positively recites <u>an overlying lower hardmask comprising a dielectric material</u>.

The foregoing remarks clearly demonstrate that the applied reference does not teach <u>each and every</u> aspect of the claimed invention, as required by <u>King</u> and <u>Kloster Speedsteel</u>; therefore the claims of the present application are not anticipated by the disclosure of Pan. Applicants respectfully submit that the instant § 102 rejection has been obviated and withdrawal thereof is respectfully requested.

Concerning the obviousness rejection, Applicants respectfully submit that the structure of the present application, as recited in currently amended Claim 1 and the dependent claims therefrom, is not rendered obvious by the disclosure of Pan. Specifically, Pan does not teach or suggest an overlying lower hardmask <u>comprising a dielectric material</u>.

The remarks made under the anticipation rejection are incorporated herein by reference.

Dielectric materials are not conductive, and consequently, cannot be the same material as any material that may be employed as a refractory metal adhesion/barrier layer disclosed in Pan. Thus, the claimed structure of the present invention necessarily comprises <u>a different material,</u> i.e., a dielectric material, than the refractory metal adhesion/barrier layer employed in Pan, which is necessarily a conductive material.

While Pan discloses use of titanium silicide or titanium/titanium nitride dual layers (See Col. 9, lines 27 – 36 of Pan), such alternatives are even further removed from the present invention because titanium silicide is a conductive material, and adding titanium (a metal) onto a titanium nitride layer makes the stack even more conductive.

Further, there is no teaching or suggestion that any dielectric material may be employed for the refractory metal adhesion/barrier layer 34 of Pan. Examination of FIG. 2D of Pan shows that electrical connection between the copper filling layer 36 and the underlying conductive area 21B requires that the refractory metal adhesion/barrier layer 34 must be conducting. If the refractory metal adhesion/barrier layer 34 of Pan were to be non-conducting, i.e., dielectric, then the copper filling layer 36 would be electrically disconnected from the underlying conductive area 21B. Thus, there would be no interconnect structure that provides electrical conduction through the dielectric layers of Pan. Such a structure would have no utility.

Since the refractory metal adhesion/barrier layer 34 employed in Pan is <u>necessarily a conductive material</u>, and the overlying lower hardmask comprising a dielectric material according to the present invention is <u>necessarily a dielectric material</u>, Pan cannot teach or suggest the structure of the present invention.

The § 103 rejection also fails because there is no motivation in the applied reference, either individually or in practicable combinations, which suggest modifying the disclosed structures to include the various elements, particularly, an overlying lower hardmask <u>comprising a dielectric material</u>, as recited in the claims of the present invention. Applicants observe that replacement of the refractory metal adhesion/barrier layer 34 in Pan with any dielectric material would electrically disconnect the underlying conductive area 21B and the copper filling layer 36

(See FIG. 2D of Pan and accompanying paragraphs) and consequently, render the interconnect structure of Pan non-functional.

Thus, there is no motivation provided in the applied reference, or otherwise of record, to make the modification mentioned above. "The mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." In re Vaeck, 947 F.2d, 488, 493, 20 USPQ 2d. 1438, 1442 (Fed.Cir. 1991).

Applicants respectfully submit that the rejection under 35 U.S.C. § 103 has been obviated; therefore reconsideration and withdrawal thereof is respectfully requested.

In view of the foregoing amendments and remarks, it is firmly believed that the subject application is in condition for allowance, which action is earnestly solicited.

Respectfully submitted,

Leslie S. Szivos, Ph.D.
Registration No. 39,394

Scully, Scott, Murphy & Presser, P.C.
400 Garden City Plaza, Suite 300
Garden City, New York 11530
(516) 742-4343
BP/LSS/av